

Pushing the Envelope: DUV Mask Inspection of 20nm EUV Masks

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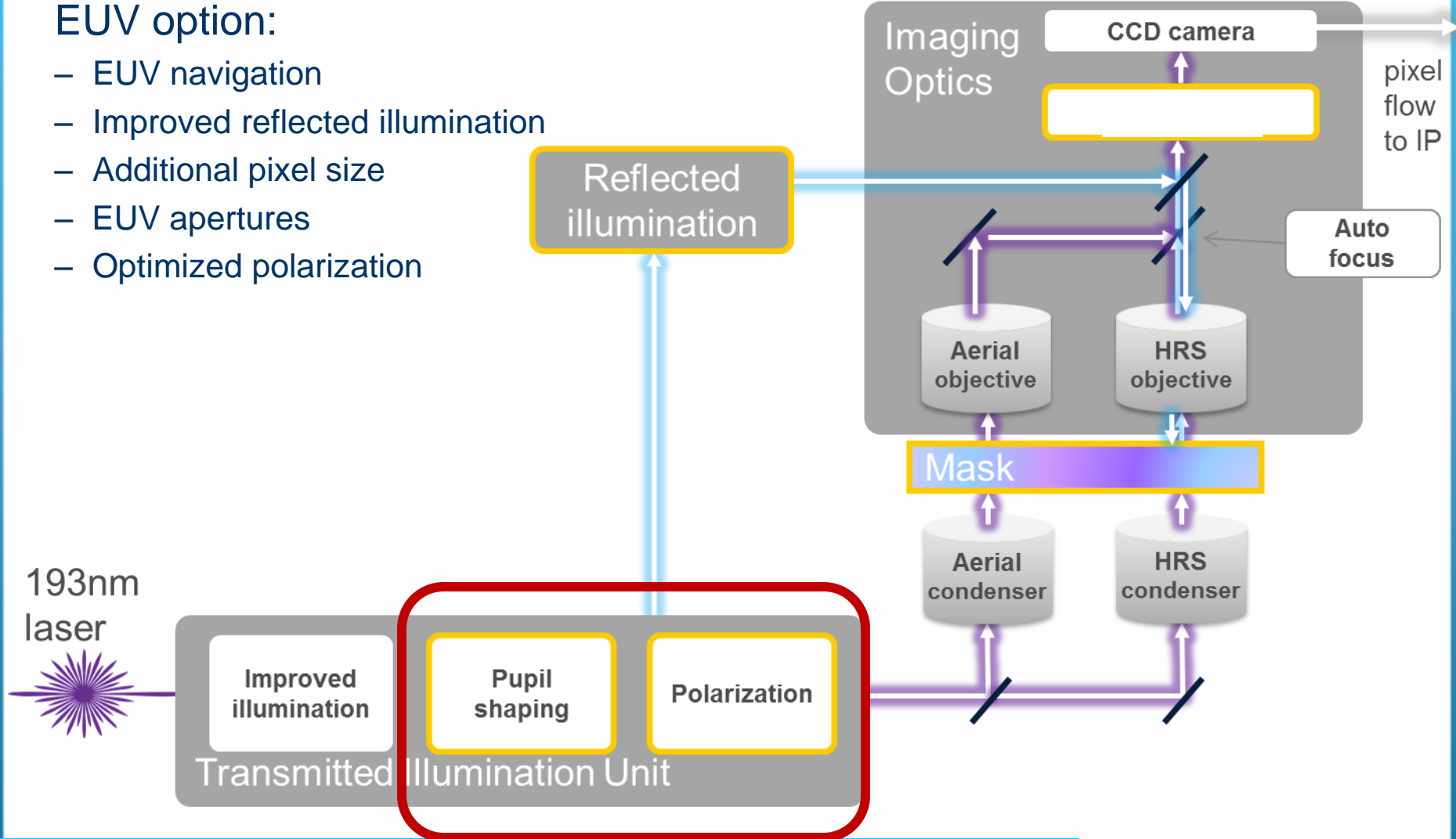


193nm EUV inspection options



EUV option:

- EUV navigation
- Improved reflected illumination
- Additional pixel size
- EUV apertures
- Optimized polarization



Key Enablers: Illumination Shaping / Polarization

Illumination Control

Dual illumination impact



Type	Break		Bridge		Protrusion	
Diff Image	Low Sigma	Dipole	Low Sigma	Dipole	Low Sigma	Dipole
Low Sigma	X		✓		✓	
Dipole-Y	✓		✓		X	

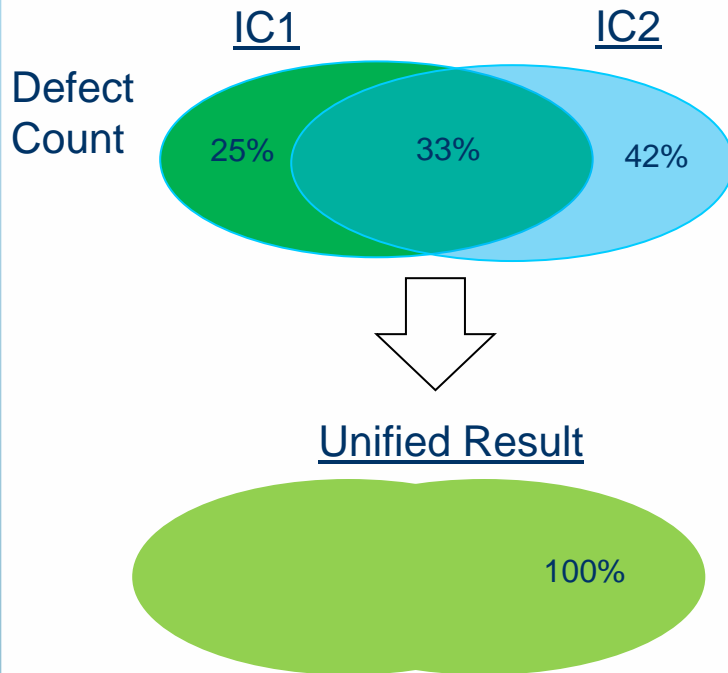
- ✓ Pattern dependent contrast/SNR optimization
- ✓ by using different Illumination Conditions
- ✓ combined with Polarization

Dual illumination inspection scheme for full coverage

Result: Two-IC Inspection Flow

2xnm L&S, PDM EUV mask

- Mask was inspected using two inspection conditions (ICs)
- Results are merged into a unified output



Defect Types	IC1	Diff Images	IC2
No signal			Significant signal
Significant signal			No signal
Significant signal			Significant signal

Full coverage at 2xnm may be provided by dual illumination inspection

Masks with Flare Bias

2xnm patterns, Flare <10% CD Bias, PDM EUV mask

■ Pure L&S

Sensitivity @ 2xnm L&S

FAs

~10

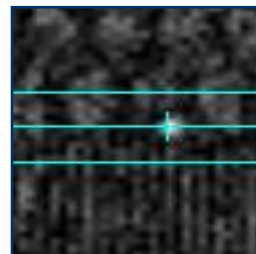
#	Below SPEC			Above SPEC				
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

■ Random (same recipe)

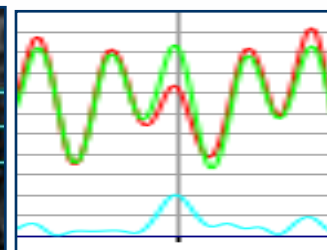
2xnm Random HV + Flare

Inspection Mode	PDM Sensitivity	FAs #
Same as L/S	Same as L/S	~10

Diff Image



Profile



- Flare CD bias, between the two dies, is seen in the difference image (as pattern residuals)
- Inspectability + Detectability - Demonstrated

Flare masks are inspectable at similar FA and detection performance



Aera @ R&D Lab vs. Aera3™ – CH

24-26nm Contact Holes Detection Results

Type	Tool	Aera3 Detection Line				Better than Aera3		
1	Aera @ R&D Lab							
2								
3								
4								

- **Aera @ R&D Lab:**

1. Smaller pixel size
2. Improved optical path
3. Improved auto-focus system



Aera @ R&D Lab vs. Aera3 - LS

24-26nm LS Detection Results

	Tool	Above Spec				Below Spec		
Extrusion	Aera3							
	Aera@R&D							
Intrusion	Aera3							
	Aera@R&D							
Pin Dot	Aera3							
	Aera@R&D							
Pin Hole	Aera3							
	Aera@R&D							

Aera @ R&D - 20nm LS Detection Results



20nm LS Detection Results

	Tool	Above Spec				Below Spec		
Extrusion	Aera @ R&D							
Intrusion								
Pin Dot								
Pin Hole								

- Detection is currently limited by mask LER



Summary

- Aera3™ beyond 30nm
 - Illumination settings per pattern type results in optimized detection and contrast enhancement
 - Masks with flare bias are inspectable

- Aera @ R&D down to 20nm
 - Incorporates Aera3™ illumination setting with improved optics and auto-focus system
 - Exceeds Aera3 detection results
 - Detection is limited by the high number of nuisance defects as a result of mask pattern noise



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APPLIED MATERIALS.